IMPROVING LEARNING WITH CONSTRUCTIVIST TECHNOLOGY TOOLS

By

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ABSTRACT

This article traces the development of the constructivist theory of teaching and learning, overviews the research that links technology to constructivism and highlights some of the teaching and learning tools, systems and models that are successfully using technology to develop learners' thinking and understanding. Constructivist viewpoints represent a range of thinking on different dynamics, such as:

- *Teacher-directed instruction vs. student-empowered learning*
- *Standardization vs. customization*
- *Solitary vs. community-based learning*
- *Simulation vs authentic experience*

There are now a variety of tools and systems available to assist with learning across these spectra. Recent research has shown that electronic performance support systems (EPSS) offer a great deal of potential for users to adapt or design the framework of their activities and their own materials to empower the learner; various multimedia combinations have shown a great deal of promise in supporting learners to create their own visual schema; simulations and virtual environments come closer to attaining the same results as real-world experiences and models that exist which will help us to organize these resources to attain optimal impact. The article closes with a review of available tools and implications for research.

INTRODUCTION

Educators and researchers are working hard to prove that technology is a tool that not only can assist learning but one that has the power to improve learning. Successful projects and applications are becoming commonplace, discrete studies abound, and there are schools of successful experiences forming, which offer some collective wisdom for practitioners. One area of congruence centers on the use of technology as a tool for constructivist teaching and learning.

Constructivist theory deserves special scrutiny today in reaction to the emphasis on achievement testing and the regression to direct teaching method as the dominant mode of instruction. These approaches are in sharp contrast with the constructivists view that learners learn and certainly in opposition to the way technology users are acquiring and applying knowledge today. Research is suggesting that constructivism could be seen as the middle road that might prevent another drastic swing away from current policies. It can be argued that constructivism has become the dominant mode of learning in the everyday lives and careers of Internet users. Technology consumers today use the Internet to satisfy their spontaneous curiosities and desires for information thus constructing much of their knowledge independent of formal schools of education.

It can be argued that constructivism can provide the foundation that guides the application of technology toward the more edifying purposes. It provides a theory of learning based on the learner's processing of information and holds promise for realizing two perennial instructional goals: i) the differentiation of learning tasks and ii) the shifting of the responsibility for learning to the individual.

This article is a by-product of a personal quest to clarify how technology can improve the learning process. It provides a brief overview of constructivist thinking, summarizes projects in which technology is used as a constructivist tool, proposes a model for constructivist

instruction and offers concrete suggestions for pairing constructivist approaches with the power of electronic technologies.

Constructivism

In constructivist learning, says Richard E. Mayer, the learning is mentally active, using a variety of cognitive processes. Learning, according to constructivist thinking, involves paying attention to relevant information, organizing that information into coherent representations, and integrating those representations with existing knowledge. Mayer distinguishes student physical activity from cognitive activity, stressing that the latter is the essential process in constructivist learning. He adds that, to determine whether a learner has effectively integrated the information, it is important to see whether she is able to call up the information and apply it to new problems or situations (Mayer, 2008).

The constructivist believe is that it is the individual learner who makes what sense he can have of the environment and the information perceived. This approach is in direct contrast to the knowledge acquisition (Mayer, 2008, p. 143) notion that, once information is organized by the instructor, it is also absorbed by the learner in that way and can be retrieved and used in various situations. This notion that it is the learner who must construct his or her own understanding is central to all leaders of the constructivist movement. Without instructional activities that move students beyond the passive act of "information acquisition" to those that requires the student to "engage in active cognitive processing" (Mayer, 2008, p. 34), the outcome for the learner may have little functional value. Constructive learning, according to Shuell (1988, p. 277-78) is necessarily:

- active - students process information meaningfully
- constructive - new information elaborated and related to other information
- cumulative - all new learning builds on prior knowledge
- reflective - learners consciously reflect on and assess what they know and need to learn
- goal-directed and intentional - learners subscribe to goals of learning

Constructivist viewpoints represent a range of thinking on different dynamics. There are "radical constructivists" who see learning as an experience unique to each individual and there are "social constructivists" who view learning as situated in social contexts mediated by the individual (Karagiorgi & Symeou, 2005, p.2). Thus, the instructional approaches advocated by different constructivists will represent a range of activities on the following dynamics:

- Teacher-guided instruction vs. student-regulated learning
- Standardization vs. customization
- Solitary vs. community-based learning
- Simulation vs. authentic experience

Across this range of views, constructivism continues to show promise when combined with the power of technology, especially when guided by an instructor who understands how to use these tools to foster student construction.

The Partnership of Constructivism & Technology

An increasing number of experts are extolling the virtues of modern technology as a tool for constructivism (e.g., Karagiorgi & Symeou, 2005; Mayer, 2008; Jonassen, Howland, Marra, & Crismond, 2007). Electronic technologies have unlimited capacity for finding information related to a question or concept, illustrating ideas in graphic and auditory forms, providing individual as well as group interaction on learning content and nonlinear linking of information. So that the brain may more easily see complex interrelationships, and simulating real-life situations or problems. These are all tools that are vital to the processes of understanding, organizing, and applying knowledge as the constructivists describe.

Because technology as a learning tool has recently come under increased scrutiny (Cuban, 2001), more focused attention has been directed to exactly what applications of technology will reap concrete benefits in learning. The recent preoccupation with achievement testing as the measurement of learning compels us to ask whether there is an evidence for the constructivist uses of

technology improve test scores. Though achievement scores would not appear to be the best measure of the type of learning constructivism aspires to, there are remarkable findings. Simons (1993, p. 296) found that those students who use a constructive or "deep" approach to learning did better on all forms of testing they studied (recall, insight, problem-solving) when compared with "surface learners" and "use-oriented learners." Much more recently, Rosen and Salomon (200, p.13) found similar results when they conducted a meta-analysis of thirty-two methodologically-appropriate experiments that compared traditional and constructivist approaches. They found that, "overall constructivist learning environments are more effective than traditional ones." This difference was even greater when constructivist-appropriate measures were used. On purely traditionally-appropriated measures, the traditional settings did not differ from the constructivist ones, illustrating that there is much to be gained and little to be lost in creating constructivist environments.

Zhang (2002) found that students learning to use the computer and the Internet had higher achievement test scores when constructivist methods were used. Rao (ND) used concept mapping, a popular constructivist tool, with science students and found they performed better on an achievement test, process skills, and a concept attainment test. Staub and Stern (2002) found that students who had teachers, and had a cognitive constructivist view of teaching and learning scored better on math achievement tests. One of the important points to be made is drawn from historical wisdom: 'achievement tests cannot measure the more profound learning that we want from our students and that constructivists aspire to'.

Other accounts of the effectiveness of computers and constructivism abound, especially with those whose emphasis is on training learners for real-world essential skills. Nanjappa (2003) cites two case studies, one with teacher candidates at Winthrop University in South Carolina (Richards, 1998), another at the Open University in U.K. (Walker, 2000) where both students and instructors reported benefiting from the use of constructivist approaches with technology. The South Carolina students showed favorable outcomes when they used electronic portfolios to engage in collaboration and cooperative learning to build literacy skills and strategies. The U.K. project reported an improvement in learning when constructivist techniques were used with distance education learners.

Brown's (1994, 1997) "communities of learners" notion has also found a cyberspace. This popular approach has been adapted on Web sites aimed at linking groups of like-minded users gathered in a virtual space to pursue common learning interests. The "cognitive apprenticeship" model developed by Collins, Brown and Newman (1990) has also been widely used with tele-mentoring programs, multimedia simulations and Web-based problem-solving activities (Amill, 1999-2000, Harry, 2000; Pringle, 2002; Virginia Tech, 2006).

Problem-and project-based learning are also prevalent constructivist methodologies that employ constructivist principles and have a strong-hold on the Internet. Cooperative learning and collaborative electronic working tools are available as well. Virtual simulations and virtual communities seek the next best thing to real field experiences.

It appears that cyberspace and other networked computer environments have discovered the appeal and power of a variety of electronic constructivist techniques and tools. It also appears, however, that many of these strategies work on a part of the constructing process but not all of it. Others will work well for specific content but not for others. The goal, as Jonassen puts it, is to develop constructivist learning environments (CLEs) that use computers as "cognitive processing tools" that assist the learner in constructing their own knowledge and skills (1996, 1999).

A Process for Classroom Construction

Some constructivists advocate an extreme laissez-faire approach to instruction, one that allows for a relatively free exploration of content led by the student and supported by an instructor. A close examination of the research reveals that most of the studies that show

improved learning gains are done in a situation where the instructor guides the activities, serving to scaffold or support the thought processes of learners (Langer, 1997; Vygotsky, 1978). The author believed that, a process that has helped the students to deepen their own thought and knowledge has evolved through experimentation with students in her own classroom for many years.

As many experienced teachers have documented, students who are accustomed to the traditional model (where the teacher imparts the information to students so that they can recall it on written tests) often resist constructivist activities initially. It is important to recognize that most schools have not fostered the skills that are necessary for successful construction. To assist them in developing the metacognitive strategies necessary for deeper learning, it is helpful to use a process that calls up past learning related to the content or skills, moving through the use of graphic organizers and analytical strategies to authentic practice or field experiences where they are required to apply their learning. The phases include the following:

1. Activate former learning
2. Integrate new learning
3. Analyze
4. Retrieve and apply
5. Synthesize

The activation of former learning through activities such as KWL charts that ask, "What do you already Know?" "What do you Want to know?" and later, "What did you Learn? erects a structure upon which new information can be built. Concept charting, writing or drawing are also effective. When this type of activity is done on computers, there is more opportunity for individual construction and reflection and the capacity for tables and graphics may add to promote visual retention for the learner. Additionally, the ability to store these individual constructions on computers, potentially in personal folders or portfolios, enhances the probability that they will be reused during and at the end of a unit of instruction.

How the information is presented is important. Richard E. Mayer has built an impressive body of research that spells out guidelines for developing multimedia development that enhances constructivist learning (Clark & Mayer, 2008; Mayer, 1999). Constant comparison of new information to previously attained information and relevant events in students' environments using questioning, discussion can become more permanent in students' minds when captured on interactive questionnaires, concept maps with tools like inspiration, discussion boards and scholarly blogs. A new product, InspireData, is a tool that allows teachers and students to construct surveys, gather instant responses and to immediately portray aggregated results in meaningful graphs for analysis. Vicarious experiences with real-world events in cyberspace can have been shown to add excitement and motivation to learning. Also online mentorships can add meaning to students' learning that the constrictions of the classroom prohibit (Emissary project, ND).

If the above techniques are used for selecting the most important concepts and comparing them to the past and present information, students will be especially ready to respond to engage in analysis activities. While social blogs can be shallow and trivial, there are exciting blogs by young learners that grow young minds by giving them a public arena to air their analyses and interpretations of issues, feelings and events. Group work facilitates analysis because learners are put in situations where their thoughts are juxtaposed to those of their peers. Online discussion provides the opportunity for individual expression and the time for thoughtful responses that often are not available in the classroom. Once again, spreadsheets, databababses, electronic graphing programs bring focus to the analytical process with visual depictions of relationships.

Many constructivists have emphasized the importance of meaningful practice of the most essential skills that the learners have to obtain (Mayer, 2008; Brown, 1997; Pringle, 2002). While the technology may not be essential to some activities such as problem solving, case studies or projects, the Web enriches these activities with its vast repositories of research, access to input by experts and linkages with persons outside the classroom sphere.

Programs such as San Diego State University's Webquests (Dodge, 2007) and Verizon's Thinkfinity (2008) partner with practitioners and professional organizations to create lessons that electronically engage students' minds and call for some form of student construction.

Though the last phase is not often mentioned by constructivists, it springs from the work of Benjamin Bloom (1956). When learners have extensive experience with a broad area of work or study, it is observed by the author that they reach a place where they are almost above the arena looking down on it. They understand the complexities of the whole and can create models, invent new approaches, make connections and judgments. These learners have constructed their own unique wisdom and are able to move about in the content easily, sharing insight as they go. If their skills include Web development, they can create an arena where others can purchase or partake of their knowledge and skills. Forming an electronic community of learners to create a cohesive interest group can be a powerful catalyst for innovative thinking and production (Table 1).

Classroom Construction	Constructivist Strategies	Technology Tools
Activate former learning	KWL charts, concept development, writing (journaling, reflecting), artwork	Tables in word processors, blogs , wikis , pre-assessment
Integrate new info	Concept mapping, database analysis, spreadsheet analysis, graphic depictions, principles for multimedia design, situated learning, peer tutoring, learner presentations	Multimedia tutorials, intelligent tutorials, InspireData,Inspiration, paint and draw programs, online questionnaires, podcasts,Word Processing,discussion boards, blogs,Vicarious adventures, online Mentors,online searching, presentation software, online organizers, e.g. TrackStar(Altec,ND),and del.icio.us(Yahoo, ND)
Analyze	Reflective thinking, predictions, compare/contrast, sort, outline, categorize, writing papers, creating presentations, case studies, expert consultation, cooperative learning, discussion	Scholarly blogs , graphic organizers, databases, spreadsheets, graphing programs, virtual expert experiences, word processors, discussion boards, online Groupwork, presentation software, Thinkfinity (Verizon,2008).
Retrieve & apply	Problem solving, projects, case studies, product creation, writing, artistic creation, cognitive apprenticeship	Web repositories of problems,WebQuests, Web development tools, word processing, mentoring projects, expert consultation, remote linkages, graphics and artistic tools
Synthesize/ evaluate	Ethical codes development, personal philosophy construction, personal mission identification and pursuit, global interaction, artistic interpretation, evaluation	Communities of learning, scholarly blogs, Web publishing tools, online journals, multimedia

Table 1.Strategies and Tools for Construction

Conclusion

It is clear that the partnership of constructivism and technology is one that holds great potential for realizing some of the aspirations we have had for modern technologies. If a teacher were to identify one deep goal/objective per unit and followed the steps using technology, discussed in this article learning may deepen and students, over time, may take more pride in their accomplishments. The process described here takes a balanced approach that most teachers can benefit from. It uses technology to leverage a path for our students that holds the promise for deeper learning and increased powers of reasoning.

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